



21st International Conference Nuclear Energy for New Europe
LJUBLJANA 2012
September 5 – 7

Nucleonica: Web-based Software Tools for Simulation and Analysis

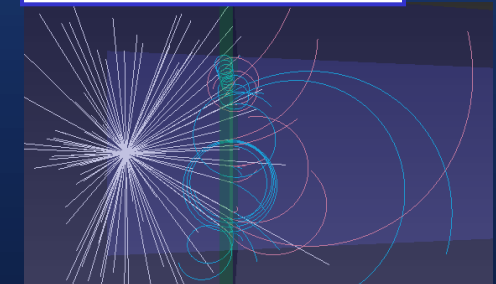
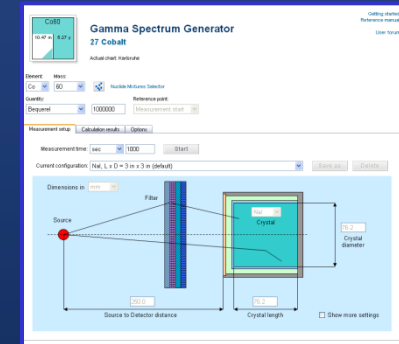
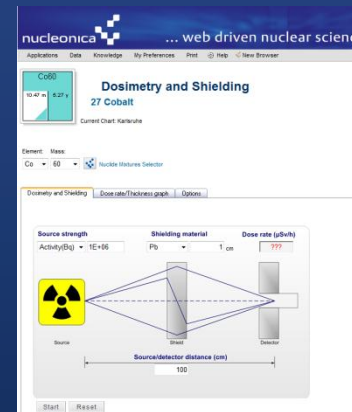
Dr. Joseph Magill,
Nucleonica GmbH,
Karlsruhe



Nucleonica: Web-based Software Tools for Simulation and Analysis



- Nuclear Data Resources in Nucleonica
- Nuclear Science Applications & Tools
 - Decay Engine
 - Dosimetry & Shielding
 - Virtual Cloud Chamber
 - Gamma Spectrum Generator
 - webKORIGEN
 - e-Ship
- Education & Training with Nucleonica
 - Post Grad. Research
 - Nucleonica Mobile
 - Karlsruhe Nuclide Chart
- Knowledge Management with Nucleonica

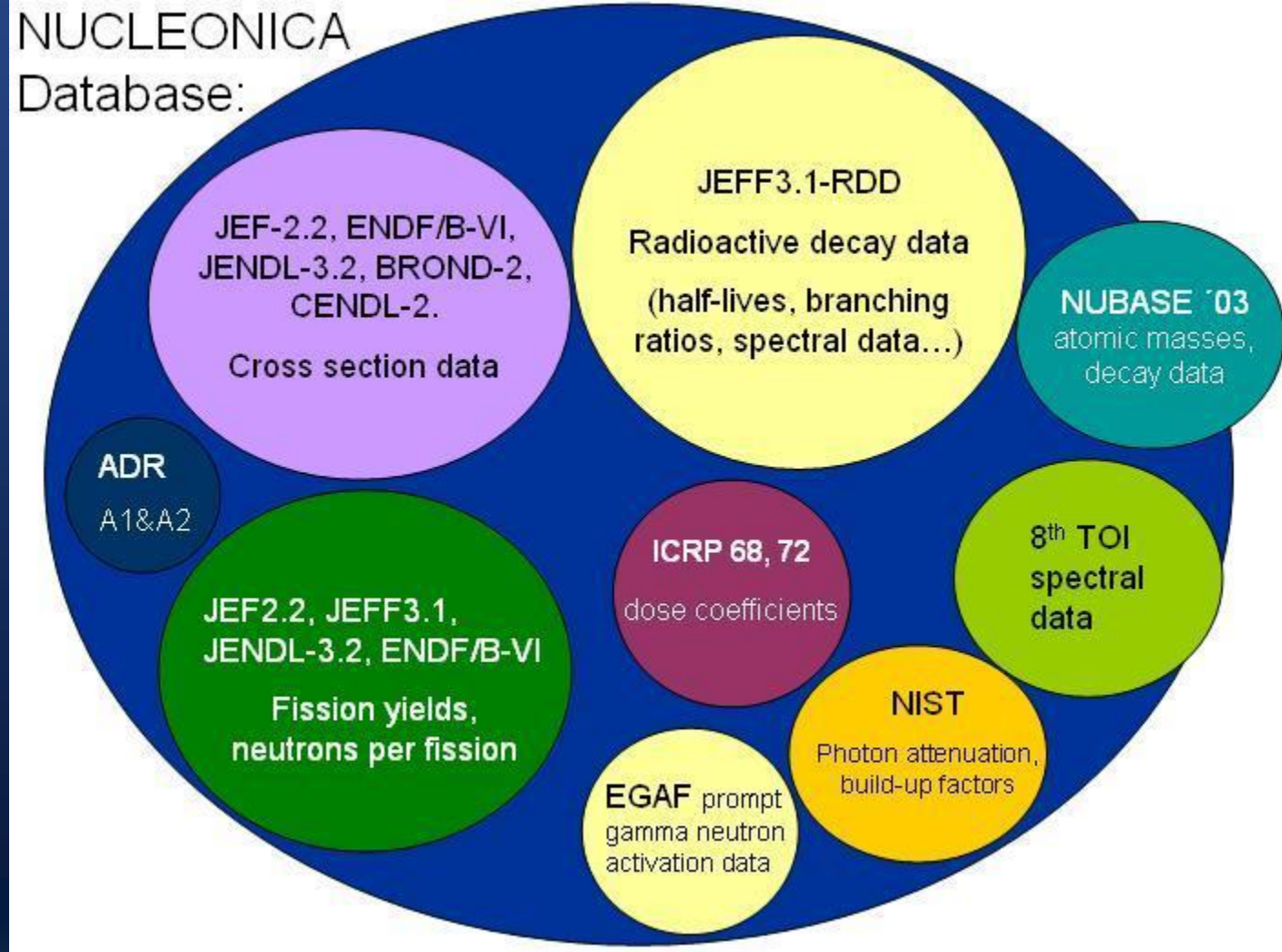


Nuclear Data Resources in Nucleonica

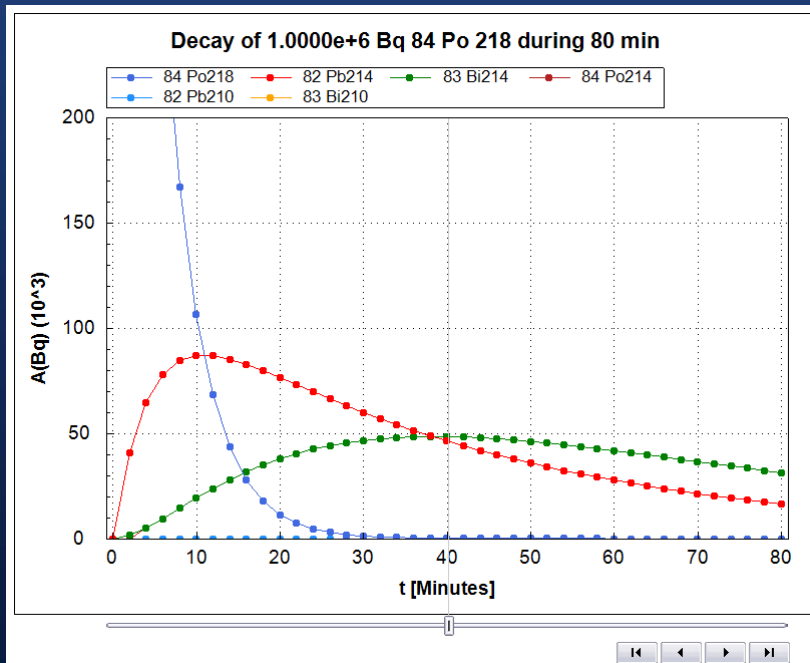
Main Nucleonica database
JEFF3.1 contains decay
data on 3852 nuclide.

NUBASE data on the
atomic weights, binding
energies, mass excesses,
and abundances,

Additional sources: 8th Table of
Isotopes, NIST, Fission Yields,
ICRP dose coeffs. The A1 and A2
from the IAEA. Properties of the
elements (densities, melting
points, boiling points etc.) and
tables of physical constants,
conversion factors and
radiological limits are from the
most recent evaluations.



Decay Engine



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Po218 3.1 m

Decay engine

84 Polonium

Current Chart: Karlsruhe

Element: Po Mass: 218

Mixture selector

Decay Engine Options Decay Tree Mixture details

Time Unit: Minutes Decay Time: 80

Starting quantity: 1.0000e+6 Final quantity: 7.92E+04 Unit: Becquerel

Start Reset Create Nuclide Mixture

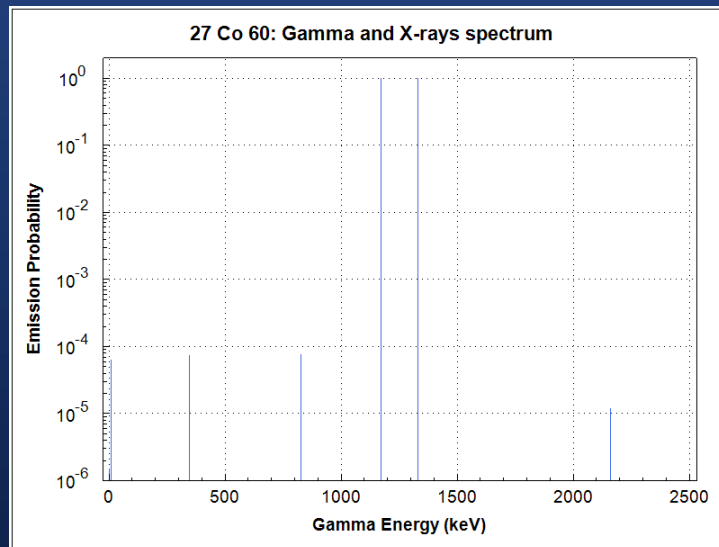
Calculation details

Number of timesteps: 40 Accuracy Factor: 1E-02 Distance (cm): 100 Number of linear chains: 1

Plot	Parent+Daughters	Half-life	Decay modes	N(atoms)	A(Bq)	A _α (Bq)	A _β (Bq)	G(keV/s)
<input checked="" type="checkbox"/>	84 Po218	3.1 m	α; β-	4.52E+00	1.68E-02	1.68E-02	3.20E-06	1.55E-04
<input checked="" type="checkbox"/>	82 Pb214	26.8 m	β-	3.83E+07	1.65E+04	0	1.65E+04	3.61E+06
<input checked="" type="checkbox"/>	83 Bi214	19.9 m	β-; α; β-,α	5.40E+07	3.13E+04	7.52E+00	3.13E+04	4.82E+07
<input checked="" type="checkbox"/>	84 Po214	1.6E2 μs	α	7.40E+00	3.13E+04	3.13E+04	0	2.64E+03
<input checked="" type="checkbox"/>	82 Pb210	22.17 y	β-; α	1.76E+08	1.74E-01	3.31E-09	1.74E-01	3.42E-01
<input checked="" type="checkbox"/>	83 Bi210	5.01 d	β-; α	3.75E+02	6.00E-04	7.92E-10	6.00E-04	1.76E-07
<input type="checkbox"/>	84 Po210	1.4E2 d	α	0	0	0	0	0
<input type="checkbox"/>	82 Pb206 Stable	stable		0	0	0	0	0
<input type="checkbox"/>	2 He4 Stable	stable		4.44E+08	0	0	0	0
<input checked="" type="checkbox"/>	Total: 9 Page: 1 / 1	0		7.12E+08	7.92E+04	3.13E+04	4.78E+04	5.18E+07

Dosimetry & Shielding

The D&S module in Nucleonica allows the user to calculate gamma dose rates from point sources of single nuclides and nuclide mixtures. The user interface is shown in figure.



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Dosimetry and Shielding
27 Cobalt
Current Chart: Karlsruhe

Element: Co Mass: 60 Mixture selector

☐ Include daughters

Dosimetry and Shielding Dose rate/Thickness graph Options Mixture details

Initial source strength: Activity(Bq) 1.0000e+6

Shielding material: Pb 0 cm

Dose rate (μSv/h): 3.37E-01

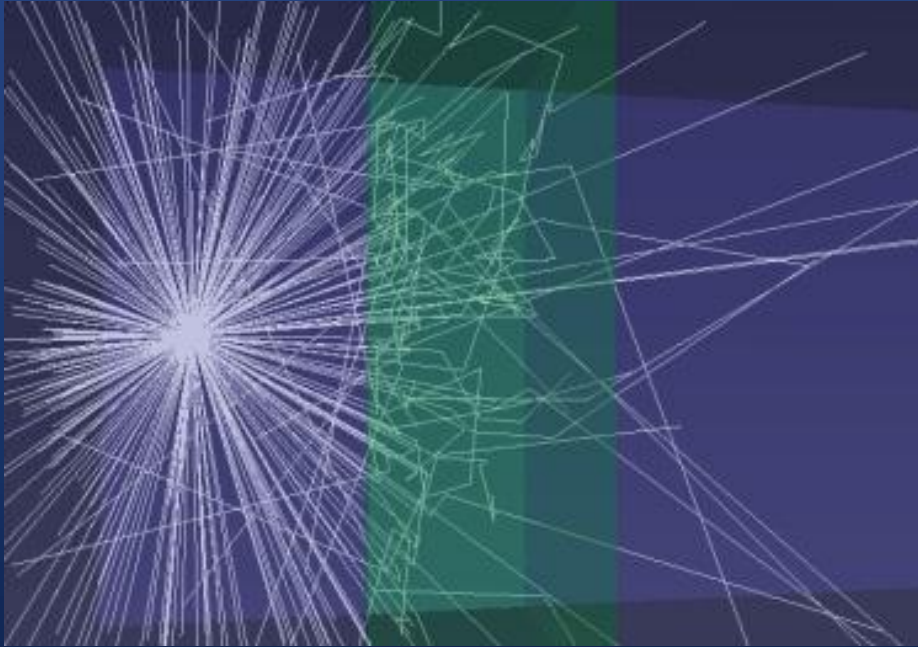
Source Shield Detector

Source/detector distance (cm): 100

Start Reset

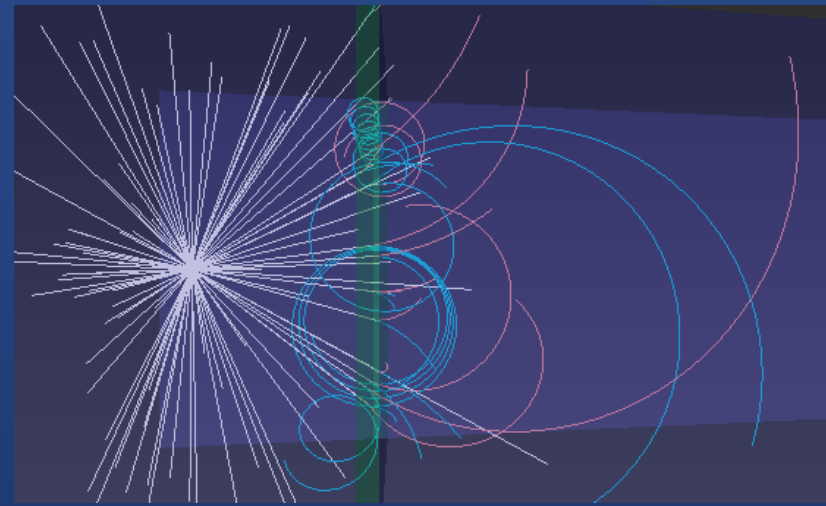
Gamma Energy (keV)	Emission Probability P (per disintegration)	Mass Attenuation Coefficient (shielding)(cm ² /g)	Number of Mean Free Paths (μ-d)	Build-up Factor	Mass Absorption Coefficient (tissue)(cm ² /g)	Tissue γ Dose Rate(μSv/h)	γ Exposure Rate(μGy/h)
1332.49	1.00E+00	0.00E+00	0.00E+00	1.00E+00	2.89E-02	1.77E-01	1.63E-01
1173.23	9.99E-01	0.00E+00	0.00E+00	1.00E+00	2.98E-02	1.60E-01	1.50E-01
826.1	7.60E-05	0.00E+00	0.00E+00	1.00E+00	3.16E-02	9.12E-06	8.30E-06
347.14	7.50E-05	0.00E+00	0.00E+00	1.00E+00	3.21E-02	3.83E-06	3.44E-06
2158.57	1.20E-05	0.00E+00	0.00E+00	1.00E+00	2.52E-02	2.99E-06	2.78E-06
2505.69	2.00E-08	0.00E+00	0.00E+00	1.00E+00	2.40E-02	5.51E-09	5.36E-09
7.47815	6.44E-05	0.00E+00	0.00E+00	1.00E+00	1.22E+01	0.00E+00	0.00E+00
7.46089	3.27E-05	0.00E+00	0.00E+00	1.00E+00	1.23E+01	0.00E+00	0.00E+00
8.26	1.31E-05	0.00E+00	0.00E+00	1.00E+00	9.01E+00	0.00E+00	0.00E+00
0.85	1.49E-06	0.00E+00	0.00E+00	1.00E+00	5.38E+03	0.00E+00	0.00E+00
Page: 1 / 1						3.37e-1	3.13e-1

Virtual Cloud Chamber

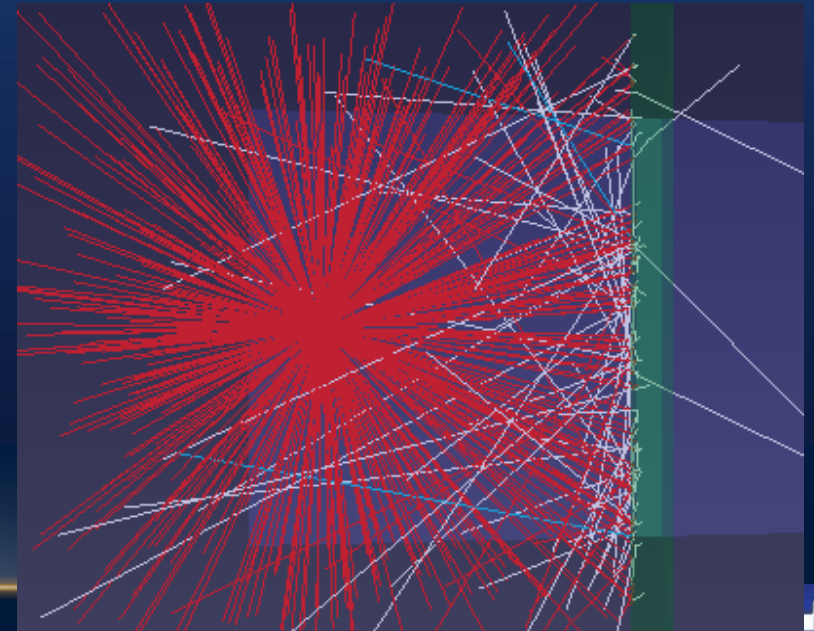


low energy photons (energy 100 keV) are attenuated with a thick (15 cm) water shield. This combination of low energies and thick shields give rise to multiple scattering of the radiation

The red particles (3 MeV positrons) are blocked by a lead shield (green). When the positrons collide with the shield, they combine with electrons (blue) to create gamma radiation (white). Only a few gamma photons pass through the shield material.

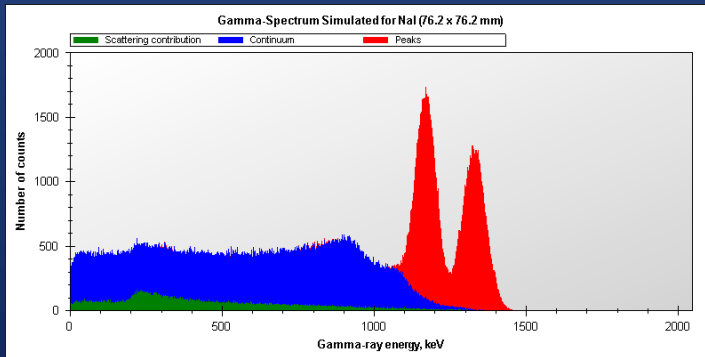


Electron-positron pairs are created using 10 MeV photons on lead. By “switching off” energy loss mechanisms, the charged particles are seen to spiral in the applied magnetic field.

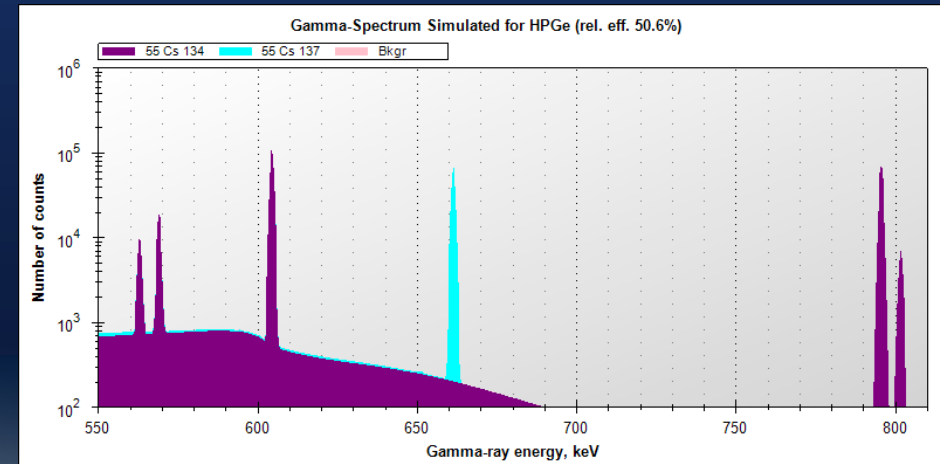
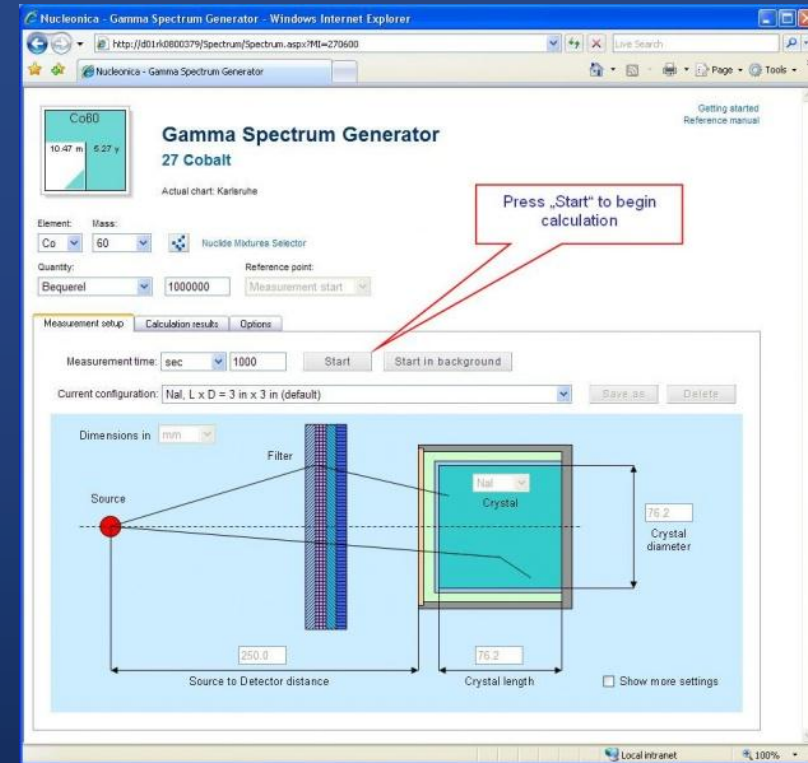
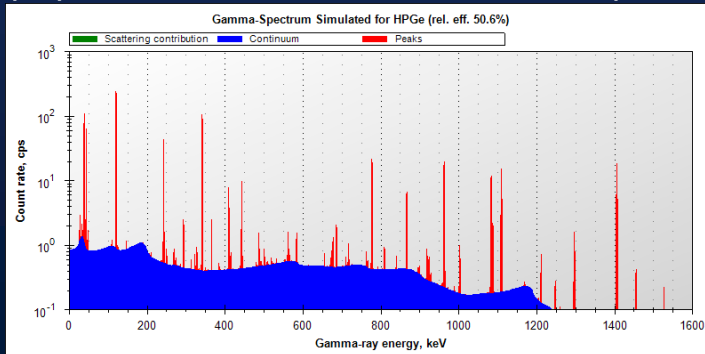


Gamma Spectrum Generator

γ -spectrum simulated for ^{60}Co 100 kBq source and NaI (3" \times 3") detector:



γ -spectrum simulated for ^{152}Eu 100 kBq source and HPGe detector.



Fukushima: Gamma spectrum of contamination at the Daiichi plant.
Contamination is almost entirely to cesium-137 and cesium -134

Validated Nuclear Science Applications & Tools

webKORIGEN



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Applications Data Knowledge My Preferences Print Networking Nuclear Science Help New Browser

Version: 2012.08.09 17:55:51



webKORIGEN

Questions, remarks, suggestions can be posted in the [forum](#)

webKORIGEN was developed from the Oak Ridge Isotope Generation and Depletion code ORIGEN. Starting with a given initial reactor fuel or a single target nuclide, it calculates the time evolution of nuclide densities changing due to decays and neutron-induced reactions, and determines derived nuclear properties such as masses, radioactivities, heat releases, radiotoxicities, emission of radiation, etc...



webKORIGEN

Questions, remarks, suggestions can be posted in the [forum](#)

webKORIGEN was developed from the Oak Ridge Isotope Generation and Depletion code ORIGEN. Starting with a given initial reactor fuel or a single target nuclide, it calculates the time evolution of nuclide densities changing due to decays and neutron-induced reactions, and determines derived nuclear properties such as masses, radioactivities, heat releases, radiotoxicities, emission of radiation, etc...

Step 1: Calculation Mode

Step 2: Reactor / Operation

Step 3: Input Summary and Run

Step 4: Display Results

Step 5: Log files

Step 6: Parameters

Display results for nuclides/elements dominant at 6 y decay

Nuclides/Elements Radiations Nuclide Chart

Display quantity: Mass (g)

Filter:

Save as Mixture ...of up to 20 selected Nuclides

Plot	Z	Nuclides	Results	Plot	Z	Elements	Results	Plots	Totals	Nuclides	Elements	Results
<input type="checkbox"/>	55	Cs133	3.416e+4	<input type="checkbox"/>	92	Uranium	1.861e+7	<input checked="" type="checkbox"/>	Actinides+Progenies:	97	19	1.887e+7
<input checked="" type="checkbox"/>	55	Cs137	3.410e+4	<input type="checkbox"/>	94	Plutonium	2.276e+5	<input type="checkbox"/>	Actinides:	61	11	1.887e+7
<input type="checkbox"/>	55	Cs135	1.208e+4	<input type="checkbox"/>	54	Xenon	1.699e+5	<input type="checkbox"/>	Transuranium:	38	7	2.610e+5
<input checked="" type="checkbox"/>	55	Cs134	6.419e+2	<input type="checkbox"/>	60	Neodymium	1.252e+5	<input type="checkbox"/>	Minor Actinides:	21	3	3.341e+4
<input type="checkbox"/>	55	Cs136	5.206e-9	<input type="checkbox"/>	40	Zirconium	1.150e+5	<input type="checkbox"/>	Radon:	3	1	1.417e-9
<input type="checkbox"/>	55	Cs138	4.691e-10	<input type="checkbox"/>	42	Molybdenum	1.084e+5	<input checked="" type="checkbox"/>	Fission Products:	725	44	1.096e+6
<input type="checkbox"/>	55	Cs139	1.107e-10	<input checked="" type="checkbox"/>	55	Cesium	8.098e+4	<input type="checkbox"/>	Lanthanides:	138	12	3.174e+5
<input type="checkbox"/>	55	Cs140	9.061e-12	<input type="checkbox"/>	58	Cerium	7.809e+4	<input type="checkbox"/>	Rare Earths:	180	14	3.445e+5
<input type="checkbox"/>	55	Cs138m	6.910e-12	<input type="checkbox"/>	44	Ruthenium	7.039e+4	<input type="checkbox"/>	Noble Metals:	90	4	1.385e+5
<input type="checkbox"/>	55	Cs141	2.523e-12	<input type="checkbox"/>	56	Barium	5.764e+4	<input type="checkbox"/>	Inert Gases (Ne, Ar, Kr, Xe):	46	2	1.808e+5
<input type="checkbox"/>	55	Cs135m	1.396e-12	<input type="checkbox"/>	46	Palladium	5.336e+4	<input type="checkbox"/>	Hydrogen:	3	1	1.275e+0
<input type="checkbox"/>	55	Cs134m	1.228e-13	<input type="checkbox"/>	57	Lanthanum	3.918e+4	<input type="checkbox"/>	Helium:	1	1	9.335e+1
<input type="checkbox"/>	55	Cs142	5.938e-14	<input type="checkbox"/>	59	Praseodymium	3.635e+4	<input type="checkbox"/>	Total:	823	64	1.997e+7
<input type="checkbox"/>	55	Cs143	1.592e-14	<input type="checkbox"/>	62	Samarium	2.612e+4					
<input type="checkbox"/>	55	Cs144	1.650e-15	<input type="checkbox"/>	43	Technetium	2.462e+4					
<input type="checkbox"/>	55	Cs145	6.462e-17	<input type="checkbox"/>	38	Strontium	2.433e+4					
<input type="checkbox"/>	55	Cs146	2.443e-18	<input type="checkbox"/>	93	Neptunium	1.574e+4					
<input type="checkbox"/>	55	Cs147	6.569e-20	<input type="checkbox"/>	95	Americium	1.534e+4					
<input type="checkbox"/>	55	Cs148	9.250e-22	<input type="checkbox"/>	39	Yttrium	1.397e+4					

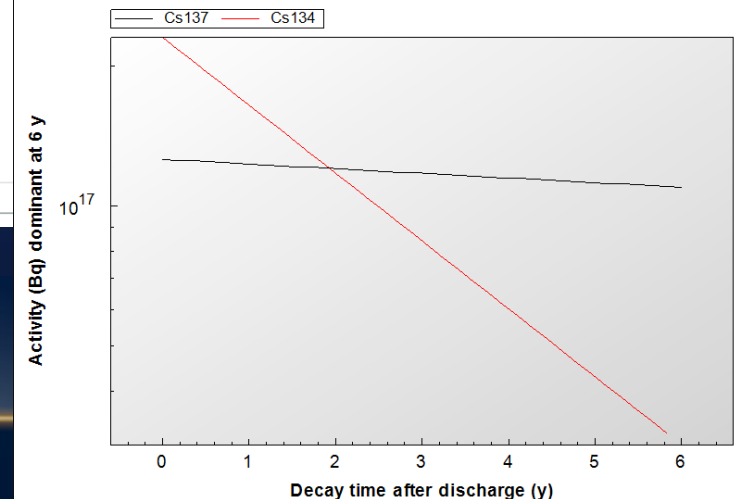
Reactor irradiation

Decay

Power
Flux

Reactor irradiation and decay

Nuclides during 6 y decay of 20 tHM PWR UOX 55 MWd/kg



Validated Nuclear Science Applications & Tools

e-Ship: radioactive transport assistant

Nuclear material transport report

Transport report generated for source: Pu-241 with daughters by magill on 8/14/2012 2:01:20 PM

Source: Pu-241 with daughters
The sample - initially 15mg Pu-241. The sample is cooled for a period of 8 years and is solid, non-special form the daughters Am-241, Np-237, and Pa-233 Pu-241 - 15 mg, 8 years old - Solid, Non special form

Form: Material, Other form, Solid

Matrix mass: 1 g


Source characterisation

Nuclide	Mass (g)	Activity (Bq)	Heat (W)	Gamma dose rate $H_{10}(\mu\text{Sv/h})$ at 10 cm
Am-241	4.77e-3	6.05e+8	5.44e-4	1.15e+3
Np-237	3.20e-5	8.35e+2	6.59e-10	1.50e-3
Pa-233	1.06e-12	8.15e+2	5.38e-11	3.34e-3
Pu-241	1.02e-2	3.90e+10	3.34e-5	3.90e+3
Total:4	1.50e-2	3.96e+10	5.78e-4	5.05e+3

Package characterisation


Nuclide	Activity (Bq)	Exempt (Bq)	Exempted (GBq)	A ₂ (TBq)	A / Exempt	A / Exempted	A / A ₂
Am-241	6.05e+8	1.00e+4	1.00e-3	1.00e-3	6.05e+4	6.05e+2	6.05e-1
Np-237	8.35e+2	1.00e+3	2.00e-3	2.00e-3	8.35e-1	4.18e-4	4.18e-7
Pa-233	8.15e+2	1.00e+7	7.00e-1	7.00e-1	8.15e-5	1.16e-6	1.16e-9
Pu-241	3.90e+10	1.00e+5	6.00e-2	6.00e-2	3.90e+5	6.50e+2	6.50e-1
Total:4	3.96e+10				4.51e+5	1.26e+3	1.26e+0

Type B Package



... web driven nuclear science

ApplicationsDataKnowledgeMy PreferencesPrintNetworkingNuclear ScienceHelpNew Browser




e-Ship
radiological transport service

My PackagesEditOptionsImportActivity limitsCERN fileSample packagesAbout e-Ship

User defined transport packages

ID	Package Name	Matrix mass (g)	Source	Form	State	Modified	Delete
(Create, import a new package)							
6	Electronic irradiated protons	1	Material	Other	Solid	2012.07.26 15:03:36	
5	Manual	1	Material	Other	Solid	2012.07.24 14:01:11	
4	Proton irradiated iron	1	Material	Other	Solid	2012.07.24 13:41:05	
38	Pu-241	15	Article	Other	Solid	2012.08.14 09:34:45	
11	Pu-241 with daughters	1	Material	Other	Solid	2012.08.10 09:05:09	
18	test	1	Material	Other	Solid	2012.07.26 15:22:04	
27	test GDR	1	Material	Other	Solid	2012.08.02 10:50:25	
37	testCo	1	Material	Other	Solid	2012.08.08 13:07:58	
19	U-233	1	Material	Other	Solid	2012.07.25 14:40:51	



e-Ship
radiological transport service

Questions, remarks, suggestions can be posted in the forum

My PackagesEditOptionsImportActivity limitsCERN fileSample packagesAbout e-Ship

Name (ID=11)
Pu-241 with daughters

Description:
The sample - initially 15mg Pu-241.
The sample is cooled for a period of 8 years and is solid, non-special form.
It now contains the daughters Am-241, Np-237, and Pa-233
Pu-241

Exempted Packages

Source

☒ Material
☐ Instruments / Articles

Form

☒ Other
☐ Special

State

☒ Solid
☐ Liquid
☐ Gas

Matrix mass: 1 g

Nuclide	Activity A (Bq)	Mass (g)	A ₁ (TBq)	A ₂ (TBq)	Exempted (GBq)	Exempt (Bq)	A / A ₂	A / Exempted	A / Exempt	Gamma dose rate $H_{10}(\mu\text{Sv/h})$ @ 10 cm	Delete
Am-241	6.05E+08	4.77e-3	10	0.001	1.00e-3	10000	0.605	605	6.05e+4	1.15e+3	
Np-237	8.35E+02	3.20e-5	20	0.002	2.00e-3	1000	4.18e-7	4.18e-4	0.835	1.50e-3	
Pa-233	8.15E+02	1.06e-12	5	0.7	0.700	1.00E+07	1.16e-9	1.16e-6	8.15e-5	3.34e-3	
Pu-241	3.90E+10	1.02e-2	40	0.06	6.00e-2	1.00E+05	0.650	650	3.90e+5	3.90e+3	
4	3.961e+10	1.500e-2					1.26	1.26e+3	4.51e+5		

Nuclide
Pu-241

Quantity
3.90E+10

Unit
Becquerel

Update

Save PackageResetCancelReportSave as Sample

Post-graduate research using Nucleonica

Nucleonica is currently being used by students for post-graduate research e.g.:

- Ph.D study of nuclear fuel cycles: The main goal is compare the amount of HLW which is stored and/or disposed for different fuel cycles, normalized to the same energy production.
- MPhil studies on modelling of atmospheric dispersion of radionuclide release from a research reactor. The aim is to compute: a) activity inventories of important radionuclides in the reactor core; b) release fractions; and c) activity released (to the atmosphere).
- Ph.D. studies medical physics: simulation of a HPGe detector used in the laboratory using the Gamma Spectrum Generator application.
- Ph.D. studies on Monte Carlo dosimetry calculations. Development of a general dosimetry and shielding application based on the CERN code GEANT4.
- MPhil studies on performance assessment of a borehole disposal facility for sealed radioactive sources. Various Nucleonica tools will be used for decay calculations, heat generation, gamma emission, neutron emission, external and internal radiotoxicities, etc.

Many of the technical problems arising in the course of these studies have been discussed on the Nucleonica Forum. Finally, we hope to be able to host the final reports from these studies on the Nucleonica web portal.

Education & Training with Nucleonica

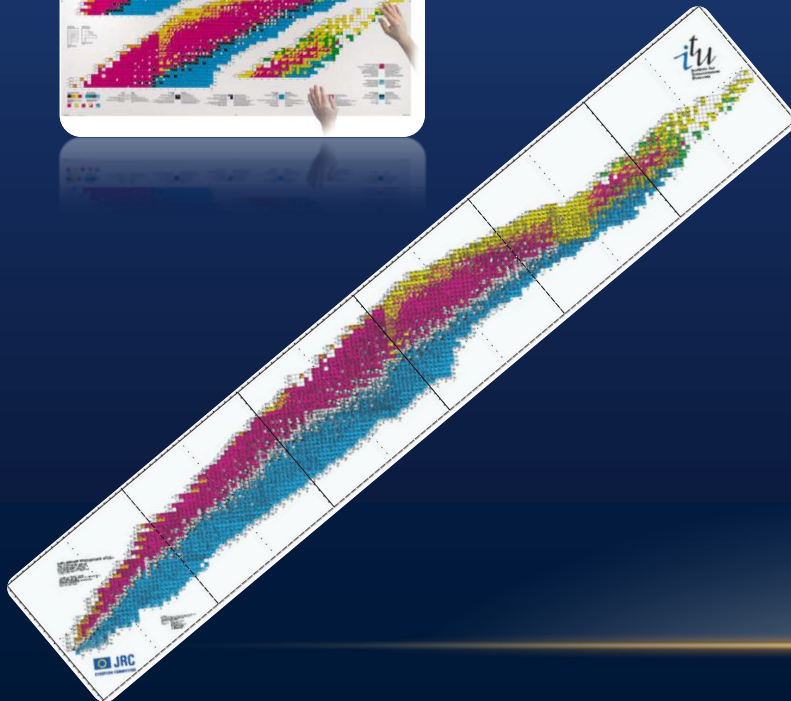
Nucleonica for Smartphones: M-Learning



Karlsruhe Nuclide Chart



- Fold-out Chart
- Wall-Chart
- Auditorium Chart
- Nuclide Carpet

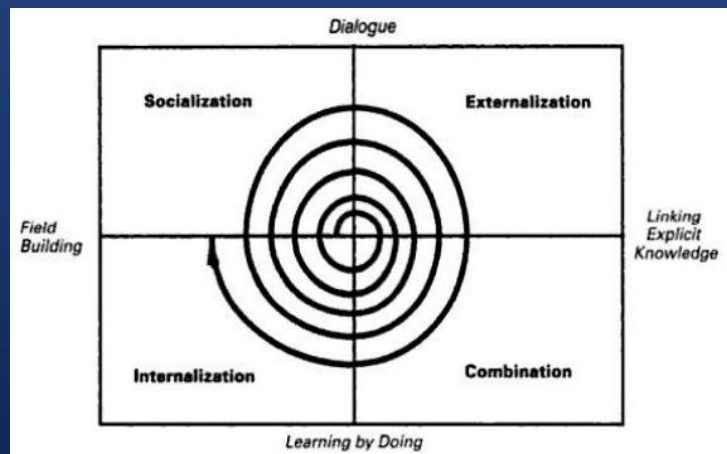


Nuclide „carpet“
1m x 6.5m

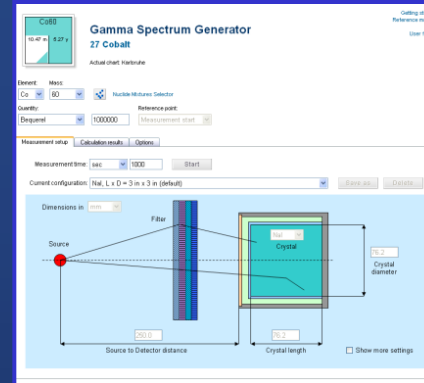


Knowledge Management with Nucleonica

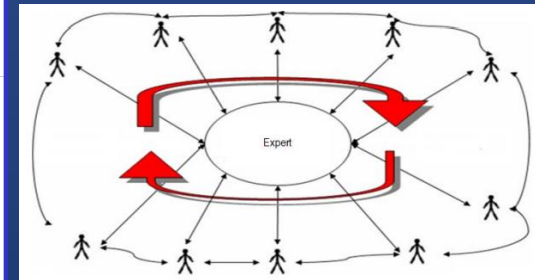
In this slide, the Nucleonica web portal is considered from a knowledge management perspective. Nonaka and Takeuchi have proposed the “knowledge spiral” (shown) in which there are four modes of knowledge conversion: socialization, externalization, combination and internalization (SECI model).



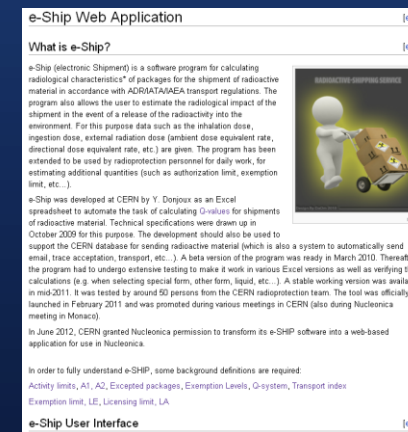
Socialisation: conversion of tacit knowledge to tacit knowledge e.g. an apprentice who works with tutor and learns from observing and imitating the tutor's actions. **Externalization:** conversion of tacit to explicit knowledge. **Combination** is the conversion of explicit to explicit knowledge. The process of systemizing already explicit knowledge into a knowledge system. **Internalization** is the conversion from explicit to tacit, which is closely related to “learning by doing”. At the end of the spiral process, one or more individuals in the organisation have acquired new tacit knowledge.



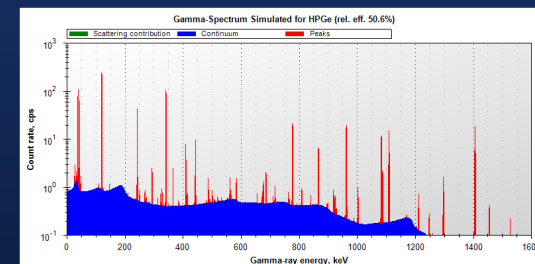
Socialisation: conversion of tacit knowledge to tacit knowledge



Externalization: conversion of tacit to explicit knowledge



Combination: systemizing explicit knowledge

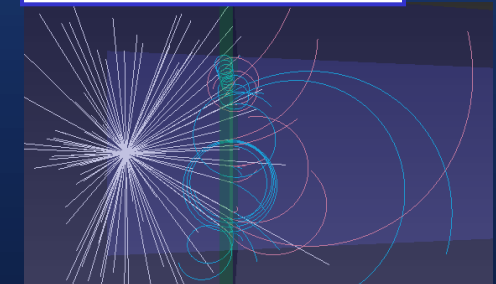
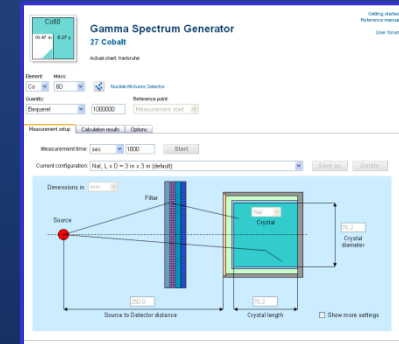
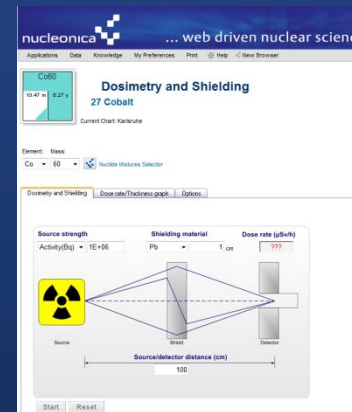


Internalization: conversion from explicit to tacit, triggered through “Learning by Doing”.

Nucleonica: Web-based Software Tools for Simulation and Analysis



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- Knowledge Management with Nucleonica



The next training course will take place on **25-26 October 2012** at the Karlsruher Institut für Technologie (KIT), FTU · Center for Advanced Technological and Environmental Training, KIT - Campus-Nord - Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen.



Thank You!